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(54) Respiratory protective apparatus

(57) A flexible hood (1) of respiratory protective apparatus envelopes the head of a wearer and includes both a mask (3) engaging the face of the wearer of the hood (1) and a neck seal (5) engaging the wearer's neck. Breathable gas from outside the hood (1) is supplied to the interior of the mask (3) independently of the interior of the hood (1). First and second exhale valves (8, 9) are mounted in the mask (3), the first exhale valve (8) communicating with the interior of the hood (1) within the neck seal and the second exhale valve (9) passing exhaled gas from the interior of the mask (3) to the surrounding atmosphere independently of the interior of the hood (1). The first exhale valve (8) is set to open at a selected positive pressure and the second exhale valve (9) is set to open at a pressure not less than, and preferably slightly higher than, the selected positive pressure so that a positive pressure is maintained in the interior of the hood (1) throughout the breathing cycle and ingress of toxic fumes into the interior of hood (1) is prevented.

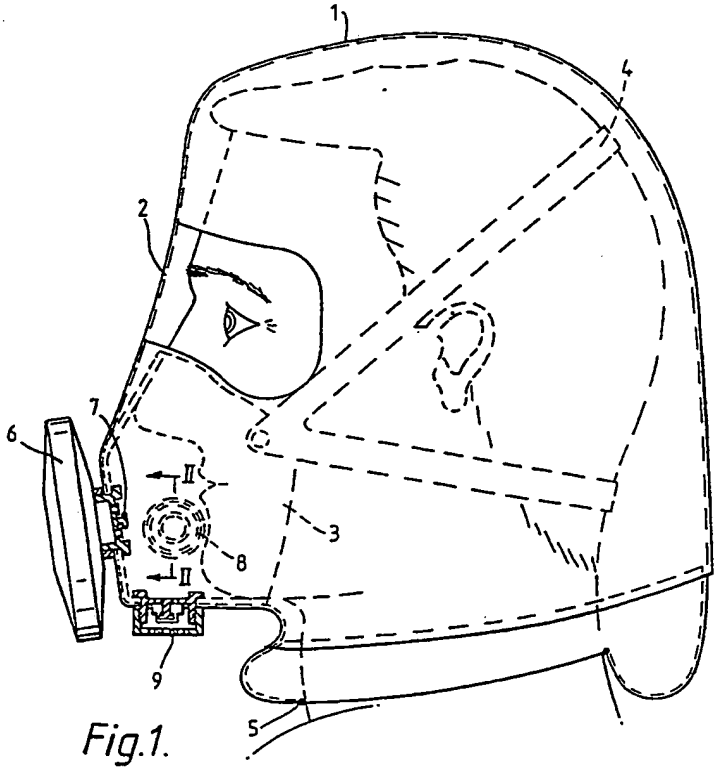

Fig.1.

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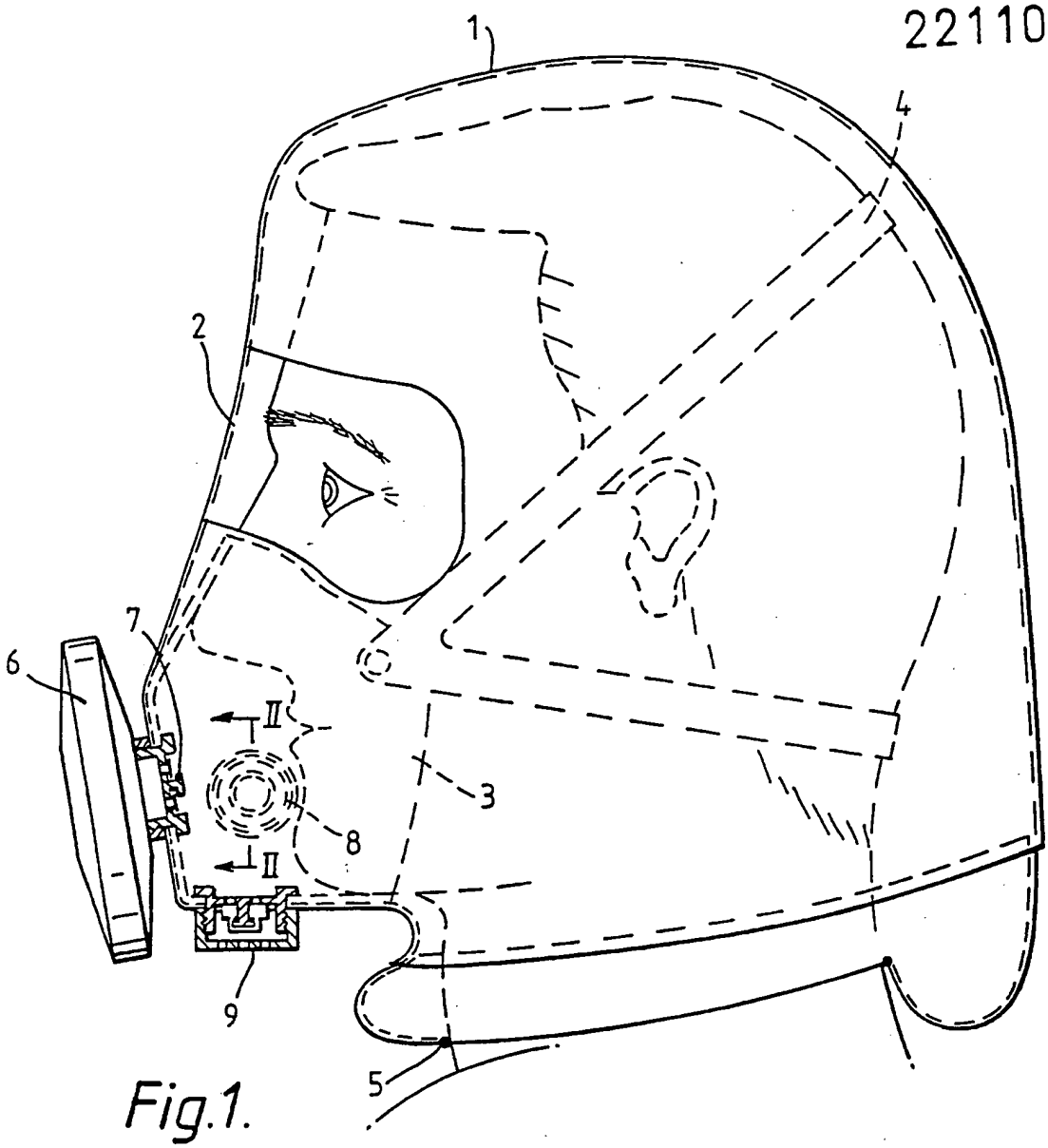

Fig.1.

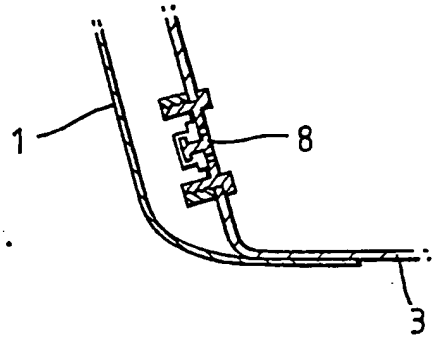

Fig.2.

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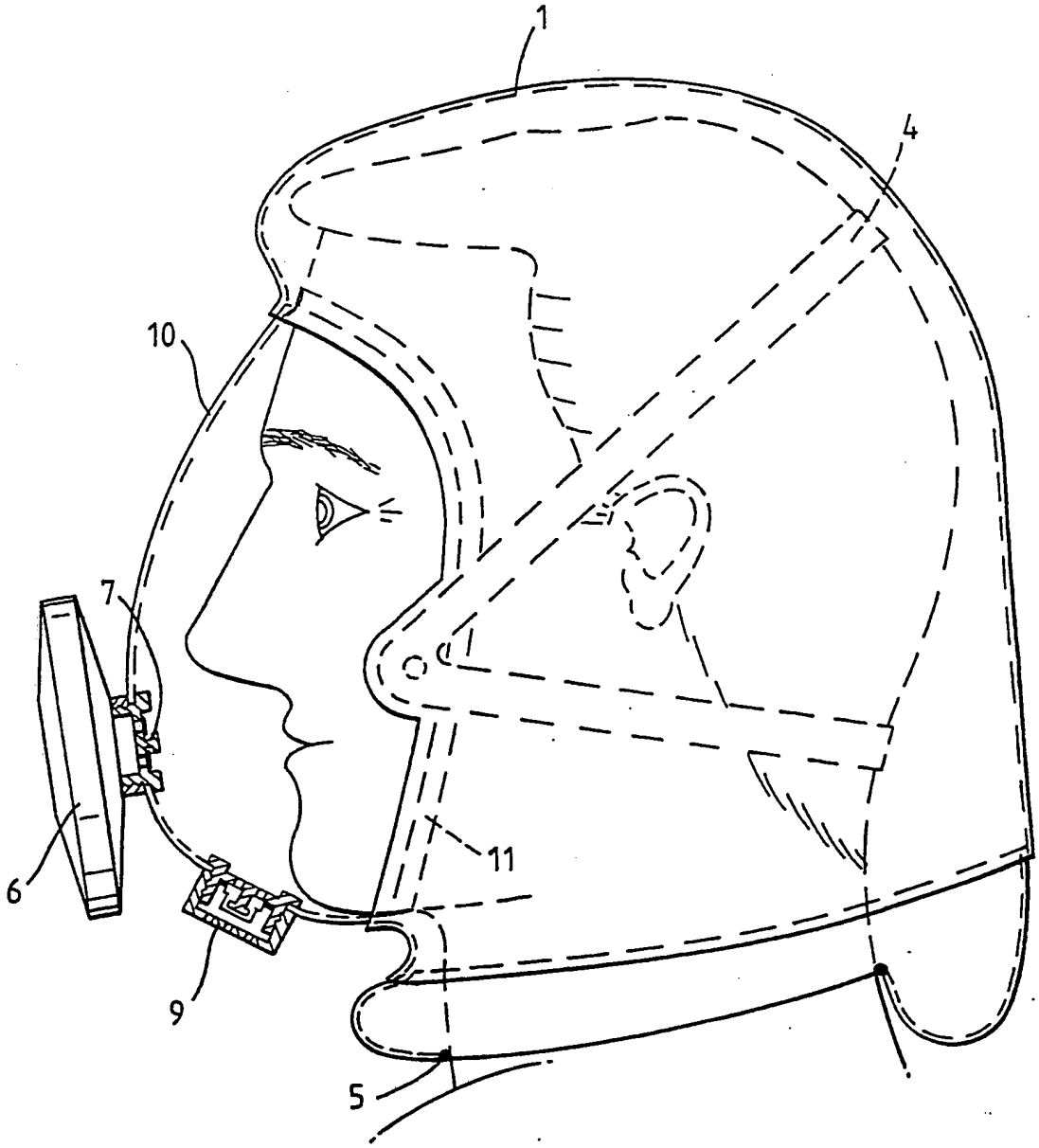

Fig.3.

RESPIRATORY PROTECTIVE APPARATUS

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This invention relates to respiratory protective apparatus and particularly to respiratory protective apparatus in which a hood is used to protect the respiratory passages, eyes, ears and head generally.

Such respiratory protective apparatus including a hood may be used with escape equipment for escape, for example, from a fire on board ship or in an aircraft. It may also be used with compressed air line equipment by personnel, for example, in nuclear power stations or when servicing chlorine installations in swimming pools. It may also be used in conjunction with an air line connected to a source of fresh air some distance from the wearer, or with a filter canister or cartridge for air inhaled directly from the surrounding atmosphere. It may also be used with an electric blower delivering air via filters.

Conventionally, hoods of respiratory protective apparatus are fitted with a neck seal of soft or corrugated material designed to limit the ingress of toxic gases from the surrounding atmosphere into the interior of the hood. Such seals are made more effective by flushing the hood with an excess flow of air which passes out through the neck seal and sweeps any toxic gases outward away from the seal preventing their ingress into the hood. The gas pressure in the hood

in this arrangement generally swings from positive to negative during the exhalation and inhalation phases of the breathing cycle. The negative pressure during the inhalation phase can be reduced and ultimately eliminated if a sufficiently high excess flow of air is supplied to the hood. However, this is wasteful of air and requires power.

A recent development of neck seal is known where the seal previously described is replaced by a septum of highly elastic polymer such as silicone or polyurethane with a small central hole. The elasticity of the material allows this hole to be expanded sufficiently to pass over the head of the wearer when donning the hood and the hole then contracts to fit around the neck and provide an excellent seal. This allows the wasteful flow of excess air to be reduced somewhat, but, if it is desired to maintain a positive pressure in the hood at all times throughout the breathing cycles, the continuous flow of air has to exceed the maximum peak inspiratory flow.

Another factor requiring a high rate of continuous air flow to a hood is the need to prevent a build-up of carbon dioxide to an unacceptably high level. An inner orinasal mask, i.e. a half mask engaging the face of the wearer around the nose and mouth, is frequently provided in the hood in order to reduce the dead space volume from which exhaled gas is reinhaled and to enable there to be some reduction in the

rate of air flow. When a half mask is fitted in the hood it is also possible to use a demand valve to control the air flow but reduction in the air flow will mean that there is no positive pressure present in the hood during an inhalation phase of the breathing cycle with the result that toxic fumes are liable to penetrate even the improved neck seal and pass into the interior of the hood. Inevitably there is also some leakage from the interior of the hood into the interior of the half mask during inhalation so that the wearer will experience discomfort to his respiratory passages as well as to his eyes.

According to the present invention there is provided respiratory protective apparatus comprising a flexible hood for enveloping the head of a wearer, a mask positioned within the hood for engaging the head of the wearer of the hood, a neck seal carried by the hood for engaging the neck of the wearer of the hood, means for supplying breathable gas from outside the hood to the interior of the mask independently of the interior of the hood, and means including first and second exhale valves for maintaining a positive pressure in the interior of the hood throughout the breathing cycle by passing exhaled gas at a positive pressure to the interior of the hood within the neck seal via the first exhale valve, and passing exhaled gas to the atmosphere outside the hood via the second exhale valve and independently of the interior of the hood at a pressure not less than said positive pressure.

In the preferred embodiment of the invention the mask is a half mask mounted in the flexible hood for engaging the face of the wearer of the hood around the nose and mouth, and both the first and second exhale valves are mounted in the half mask.

According to this preferred embodiment of the invention therefore there is provided respiratory protective apparatus comprising a flexible hood for enveloping the head of a wearer, a half mask mounted in the flexible hood for engaging the face of the wearer of the hood around the nose and mouth, a neck seal carried by the hood for engaging the neck of the wearer of the hood, means for supplying breathable gas from outside the hood to the interior of the half mask independently of the interior of the hood, a first exhale valve mounted in the half mask for passing exhaled gas from the interior of the half mask to the interior of the hood within the neck seal, and a second exhale valve mounted in the half mask for passing exhaled gas from the interior of the half mask to the surrounding atmosphere independently of the interior of the hood, the first exhale valve being set to open at a selected positive pressure, and the second exhale valve being set to open at a pressure not less than the said selected positive pressure, whereby a positive pressure is maintained in the interior of the hood throughout the breathing cycle and ingress of toxic fumes into the interior of the

hood is inhibited.

In an alternative embodiment the mask is a full face mask mounted in the flexible hood and having a flexible seal for engaging the head of the wearer of the hood to enclose the whole face of the wearer, the first exhale valve is a flap valve formed by the flexible seal of the full face mask, and the second exhale valve is an exhale valve mounted in the full face mask. The major part of the full face mask used in this embodiment is preferably formed of transparent material.

Preferably the neck seal is a septum of elastic polymer having a central hole to fit the neck of the wearer and extendible to pass over the head of the wearer when donning the hood. Advantageously the best available seal is formed at the junction of the half mask or full face mask with the face or head of the wearer and also at the neck seal.

The main advantage of respiratory protective apparatus according to the present invention is that a positive pressure is maintained inside the hood at all times throughout the breathing cycle without the need for providing a high rate of flow of air or other breathable gas. The breathable gas may simply be air inhaled from the surrounding atmosphere through a suitable filter and an inhale valve. Alternatively the breathable gas may be supplied from a source of compressed air or other gas via a demand valve.

In operation of respiratory protective apparatus according to the present invention most of the exhaled carbon dioxide is expelled to atmosphere through the second exhale valve, and the carbon dioxide content of the interior of the hood is kept low because it is the first part of the exhaled breathing flow which passes to the interior of the hood.

The present invention will be further understood from the following detailed description of preferred embodiments thereof which is made, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a diagrammatic representation in side view and in part section of one embodiment of respiratory protective apparatus in accordance with the present invention,

Figure 2 is a cross-sectional view of part of the apparatus of Figure 1 taken along the line A-A of that Figure, and

Figure 3 is a diagrammatic representation in side view and in part section of a second embodiment of respiratory protective apparatus in accordance with the present invention.

In the drawings the same or similar parts are designated by like reference numerals.

Referring to Figures 1 and 2 there is shown a flexible hood 1 of a commercially available flame resistant composite formed of a suitable plastics material laminated to a woven base. A visor 2 of

a rigid transparent plastics material, for example perspex or polycarbonate, constitutes a wrap-around window heat welded to the flexible hood 1. A flexible half mask 3, for example a rubber half mask, is mounted to the interior of the hood 1 immediately below the visor 2. The half mask 3 reduces the dead space volume and also prevents fogging of the visor 2 by preventing moist warm exhaled gas flowing across it. The half mask 3 is retained in engagement with the face of the wearer of the hood around the nose and mouth by a conventional head harness 4 within the hood 1.

A neck seal 5 consisting of a septum of highly elastic polymer such as silicone or polyurethane is secured to a lower part of the hood 1, for example by welding or adhesive, and engages the neck of the wearer to provide a good seal.

Breathable gas is inhaled direct to the interior of the half mask 3 from the surrounding atmosphere through a filter canister or cartridge 6 which is connected to a non-return inhale valve 7. Filtered air is thus passed through the filter canister 6 and the inhale valve 7 to the interior of the half mask 3 independently of the gas in the interior of the hood 1 outside the half mask 3.

In addition to the non-return inhale valve 7, there are mounted in the half mask 3 first and second non-return exhale valves 8 and 9. The first exhale valve 8, which is set to open at a small positive

pressure, for example ten millimetres water gauge, communicates with the interior of the hood 1 outside the half mask 3. The second exhale valve 9 which is set to open at the same or, preferably, at a higher, but still low, positive pressure, for example twenty to twenty-five millimetres water gauge, connects the interior of the half mask 3 directly to the external or surrounding atmosphere, that is to say independently of the interior of the hood 1.

In operation, the pressure inside the half mask 3 will generally vary from positive, during exhalation, to negative during the inhalation phase of the breathing cycle.

During exhalation, when the pressure rises, the first exhale valve 8 will open, discharging a small amount of exhale gas including some carbon dioxide vapour to the interior of the hood 1. As the pressure rises further, due to the resistance of the hood 1 and neck seal 5, the second exhale valve 9 opens and discharges the majority of the exhale gas to atmosphere. This second and major part of the exhale breathing flow contains most of the exhaled carbon dioxide which is therefore expelled to atmosphere rather than being retained in the hood 1 and this is an advantage of the present invention. However, the main advantage of the invention is that it maintains a positive pressure inside the hood throughout the breathing cycle.

At the time in the breathing cycle when both

the first and second exhale valves 8 and 9 are open, the interior of the hood 1 is connected to the external atmosphere via the first exhale valve 8, the interior of the half mask 3 and the second exhale valve 9, but the pressure within the half mask 3 ensures that any flow of gas through the second exhale valve 9 is an outward flow.

As the exhalation phase is completed and the pressure inside the half mask 3 begins to drop, the second exhale valve 9 shuts, cutting off the half mask 3 and hood 1 from the external atmosphere. Subsequently, at a lower pressure, the first exhale valve 8 also shuts, trapping the positive pressure inside the hood 1 which therefore generally remains between the cracking pressures of the first and second exhale valves 8 and 9.

The pressure inside the half mask 3 continues to drop and becomes negative during the inhalation phase. However, as the first exhale valve 8 remains shut, and provided only that there is a reasonable seal between the half mask 3 and the hood 1 - which is achieved by careful design of the edge of the half mask 3 where it abuts the face in order to ensure an adequate seal with all shapes and sizes of face - the pressure in the hood 1 will remain positive throughout this inhalation phase, although it may drop somewhat due to a small leakage from the hood 1 via the neck seal 5 to atmosphere and from the hood

1 into the half mask 3. When both these seals are well designed, this leakage remains small in relation to the volume of the interior of the hood 1, and the pressure in the hood 1 remains positive at all times.

Referring now to Figure 3 of the accompanying drawings there is shown an embodiment of respiratory breathing apparatus in which a transparent full face mask 10 is used in place of the visor 2 and the half mask 3. The full face mask 10 has a flexible seal 11 round its edge. The flexible seal 11 is of such a flexibility that it will come away from the face of the wearer during the exhalation phase when the pressure in the full face mask 10 rises, for example, to ten millimetres water gauge, and sufficient resilience to spring closed on inhalation against the positive pressure when this falls to about the same level. The flexible seal 11 thus constitutes a flap valve which is the first exhale valve of this embodiment of the invention and which permits exhaled gases to pass at a positive pressure to the interior of the hood 1 within the neck seal 5.

The remainder of the respiratory protective apparatus of Figure 3 is similar to the apparatus of Figure 1 and operates in similar manner. At the end of the exhalation phase and the commencement of the inhalation phase, after the second exhale valve 9 (which is the only non-return exhale valve mounted in the full face mask 10 of this embodiment of the

invention) is shut, the flexible seal 11 re-engages the face, as the flap valve constituted by the flexible seal 11 closes, thereby trapping the positive pressure inside the hood 1.

By maintaining a positive pressure in the hood 1 at all times throughout the breathing cycle, inflow of toxic gases into the hood 1 and therefore from the hood 1 into the half mask 3 and the breathing passages of the wearer, is prevented by means of the present invention. Thus a safeguard is provided against a leaky seal or a puncture in the hood 1, and this is done without wasteful use of excess air flow and without the use of external power or the consumption of additional external energy.

The embodiments of the present invention described with reference to the accompanying drawings may equally be used with alternative supplies of breathable air, for example air supplied from a low pressure air supply via a demand valve so that air is supplied only as it is required.

Although the embodiments of the invention illustrated in the accompanying drawings show designs of hood 1 which fit fairly closely to the shape of the wearer's head, the invention equally has application to more loosely-fitting hoods in which the interior of the hood outside the half mask or full face mask has a substantially larger volume.

The principle of the present invention may also

be used on respiratory protective apparatus which is a closed circuit breathing system.

CLAIMS:

1. Respiratory protective apparatus comprising a flexible hood for enveloping the head of a wearer, a mask positioned within the hood for engaging the head of the wearer of the hood, a neck seal carried by the hood for engaging the neck of the wearer of the hood, means for supplying breathable gas from outside the hood to the interior of the mask independently of the interior of the hood, and means including first and second exhale valves for maintaining a positive pressure in the interior of the hood throughout the breathing cycle by passing exhaled gas at a positive pressure to the interior of the hood within the neck seal via the first exhale valve, and passing exhaled gas to the atmosphere outside the hood via the second exhale valve and independently of the interior of the hood at a pressure not less than said positive pressure.

2. Respiratory protective apparatus according to Claim 1 wherein the mask is a half mask mounted in the flexible hood for engaging the face of the wearer of the hood around the nose and mouth, and both the first and second exhale valves are mounted in the half mask.

3. Respiratory protective apparatus according to Claim 1, wherein the mask is a full face mask mounted

in the flexible hood and having a flexible seal for engaging the head of the wearer of the hood to enclose the whole face of the wearer, the first exhale valve is a flap valve formed by the flexible seal of the full face mask, and the second exhale valve is an exhale valve mounted in the full face mask.

4. Respiratory protective apparatus according to any one of Claims 1 to 3, wherein the neck seal comprises a septum of elastic polymer having a central hole to fit the neck of the wearer and extendible to pass over the head of the wearer when donning the hood.

5. Respiratory protective apparatus according to any one of Claims 1 to 4, wherein the means for supplying breathable gas includes a non-return inhale valve.

6. Respiratory protective apparatus according to any one of Claims 1 to 4, wherein the means for supplying breathable gas includes a demand valve.

7. Respiratory protective apparatus comprising a flexible hood for enveloping the head of a wearer, a half mask mounted in the flexible hood for engaging the face of the wearer of the hood around the nose and mouth, a neck seal carried by the hood for engaging the neck of the wearer of the hood, means for supplying breathable gas from outside the hood to the interior of the half mask independently of the interior of

the hood, a first exhale valve mounted in the half mask for passing exnaled gas from the interior of the half mask to the interior of the hood within the neck seal, and a second exhale valve mounted in the half mask for passing exhaled gas from the interior of the half mask to the surrounding atmosphere independently of the interior of the hood, the first exhale valve being set to open at a selected positive pressure, and the second exhale valve being set to open at a pressure not less than the said selected positive pressure, whereby a positive pressure is maintained in the interior of the hood throughout the breathing cycle and ingress of toxic fumes into the interior of the hood is inhibited.

8. Respiratory protective apparatus as hereinbefore described with reference to the accompanying drawings.

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